

THE ULTRASONIC WAVES EFFECTS ON OIL-WATER
EMULSIFICATION, COALESCENCE, DETACHMENT, MOBILIZATION
AND VISCOSITY IN POROUS MEDIA

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This thesis is dedicated to my beloved wife who has been a great source of motivation and inspiration. Also, this thesis is dedicated to my parents who have supported me all the way since the beginning of my studies.

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ABSTRACT

Ultrasonic wave technique is an unconventional EOR method, which has been of interest to researchers for more than six decades. Emulsification and demulsification are phenomena which occur at the interface of oil and water under the influence of ultrasonic waves. Therefore, the conditions in which emulsification becomes dominant over demulsification due to ultrasonic radiation in porous media should be further investigated. However, surfactants are the principal agents that enable oil and water to mix and are often the most expensive component in an emulsion. Therefore, selecting an appropriate surfactant formulation capable of mobilization of oil without significant surfactant loss due to adsorption and phase separation in the reservoir is very important. Estimation of solubilization parameters are great tools in designing economical emulsion flooding compositions. In this study, the effect of ultrasonic waves on the amount of oil and water solubilized by a unit of surfactant were investigated. It was observed that the emulsion volume and amount of oil solubilized in emulsion were increased by increasing salinity under short periods of ultrasonic wave radiation, and demulsification of the emulsion occurred after longer period of radiation. In addition, Hele-Shaw model tests were conducted to show microscopically the effect of long and short periods of ultrasonic waves' radiation at the interface of paraffin oil and surfactant solution/brine. Diffusion of phases, formation of emulsion and gas bubbles were observed after short periods of ultrasonic waves' radiation. However, demulsification and coalescence of surfactant solution/brine droplets inside emulsion was initiated after long periods of ultrasound radiation. Another objective of this study was to investigate directly the effect of ultrasonic waves on viscosity changes in three types of oil (paraffin oil, synthetic oil, and kerosene) and a brine sample. It was observed that the viscosity of all the liquids was decreased under the influence of ultrasonic waves in both uncontrolled and controlled temperature conditions. However, the reduction was found to be more significant for uncontrolled temperature condition cases. In addition, micro-model experiments were conducted to show other oil recovery mechanisms such as oil droplet coalescence, oil mobilization, and oil detachment from dead end pores under the influence of ultrasonic waves. The results revealed that these mechanisms happen in porous media under the influence of ultrasonic waves. Therefore, it was concluded that the use of ultrasonic waves could be suggested, not as a substitute for conventional EOR methods, but as an alternative or complimentary tool, which in certain instances may make conventional methods more effective and less costly.

ABSTRAK

Teknik gelombang ultrasonik adalah kaedah EOR bukan konvensional yang telah menarik minat ramai penyelidik sejak lebih dari enam dekad. Emulsifikasi dan demulsifikasi adalah fenomena yang terbentuk pada antaramuka diantara minyak dan air di bawah pengaruh gelombang ultrasonik. Dengan itu, keadaan di mana emulsifikasi menjadi dominan berbanding demulsifikasi akibat sinaran ultrasonik dalam media berliang harus dikaji selanjutnya. Namun begitu, surfaktan adalah agen penting yang membolehkan minyak dan air bercampur dan umumnya merupakan komponen yang paling mahal dalam emulsi. Oleh demikian, memilih formulasi surfaktan yang sesuai bagi membolehkan mobilisasi minyak tanpa kehilangan surfaktan yang signifikan disebabkan jerapan dan pemisahan fasa dalam reservoir adalah sangat penting. Menganggar parameter pemelarutan adalah alatan penting dalam merekabentuk komposisi banjiran emulsi secara ekonomik. Dalam kajian ini, kesan gelombang ultrasonik ke atas jumlah minyak dan air terlarut oleh satu unit surfaktan adalah dikaji. Hasil cerapan didapati isipadu emulsi dan jumlah minyak terlarut dalam emulsi adalah meningkat dengan peningkatan kemasinan di bawah radiasi gelombang ultrasonik dalam jangkamasa pendek. Selain itu, ujian secara mikroskopik menggunakan model Hele-Shaw menunjukkan yang kesan radiasi gelombang ultrasonik pada masa jangka masa yang panjang dan pendek pada antaramuka minyak parafin dan larutan/air garam surfaktan. Penyebaran fasa, pembentukan emulsi dan buih-buih gas dapat diperhatikan selepas radiasi gelombang ultrasonik dalam jangka masa pendek. Namun begitu, demulsifikasi dan pegabungan titisan larutan/air garam surfaktan di dalam emulsi telah terjadi selepas radiasi ultrabunyi pada jangka masa panjang. Objektif seterusnya bagi kajian ini adalah untuk mengkaji secara langsung kesan gelombang ultrasonik ke atas perubahan kelikatan ke atas tiga jenis minyak (minyak parafin, minyak sintetik, dan kerosen) dan satu sampel air garam. Didapati kelikatan bagi semua cecair adalah berkurang dengan pengaruh gelombang ultrasonik bagi kedua-dua keadaan suhu sama ada suhu terkawal atau tanpa kawalan. Sebagai tambahan, eksperimen mikro-model telah dijalankan bagi menilai mekanisme perolehan minyak yang lain seperti pegabungan titisan minyak, mobilisasi minyak dan pengenyahan minyak dari hujung liang di bawah pengaruh gelombang ultrasonik. Dengan itu, dapat dibuat kesimpulan yang penggunaan gelombang ultrasonik boleh dicadangkan, bukan sebagai pengganti bagi kaedah EOR konvensional, tetapi sebagai satu pilihan atau alatan sampingan, yang mana dalam keadaan tertentu boleh membuat kaedah konvensional lebih berkesan dan dengan kos yang rendah.